THE ART AND SCIENCE OF SIGNIFICANT FIGURES

HOW TO DO MATH IN CHEMISTRY

This presentation is a sequence of scenes that take students from thinking about measurement, to how to work with the numbers properly when using them to solve math problems.

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INTRODUCTION

TARGET LEARNERS

The target learners are chemistry students. Ideally all high school chemistry students are taught about significant figures, but some teachers do not teach about it. In these situations there are students heading off to college where the professors expect students to use the correct significant figures in their answers, but for many college students who have never seen the concept before, it is very overwhelming. The finished version will be put up at YouTube so that any chemistry student can play with the presentation and become comfortable with what significant figures are and how to do calculations with them.

PURPOSE AND OBJECTIVES

1. Students will identify how many significant digits or significant figures are in a particular number made of numbers 1-9.
2. Students will identify how many significant digits or significant figures are in numbers that include zero.
3. Students will identify how many significant digits or significant figures are in numbers expressed in scientific notation.
4. Students will be able to determine how to round numbers to a specific amount of significant digits/figures.
5. Students will follow rules of significant figures when doing multiplication or division to round final answers correctly.
6. Students will use dimensional analysis to determine how many significant figures should be in a final answer.
7. Students will be able to round final answers to the correct amount of significant figures after performing addition or subtraction.

EQUIPMENT YOU NEED

HARDWARE REQUIREMENTS

a. Computer- a computer that can handle Flash player 10.3 and higher.
b. Peripherals-
    i. speakers to hear sound effects
    ii. mouse to maneuver through the scenes
c. Monitor- that will let an 800 x 800 screen be seen in one piece

SOFTWARE REQUIREMENTS

a. Operating System

    Any that can handle playing Flash documents and Articulate documents. Both should be able to be viewed in a common browser

like Firefox or Internet Explorer that have Flash Player add-ons / plug-ins

b. Application Programs
    i. A Brower that can handle Flash animations and playing videos should be needed
    ii. Flash Player version 10.3 or newer

c. Specific Web Browser
    i. Firefox recommended
    ii. Internet Explorer 9 or higher
    iii. Safari 5 or higher
    iv. Depending on the computer's settings, the screen resolution may need to be made smaller by using control-minus, Ctrl-, to shrink the viewable screen. The program's dimensions are set to 800 px x 800 px.

NETWORK CONNECTIONS

Naturally high speed is always better than dial-up. The program has been tested on wired and wireless connections and worked smoothly in both.

GETTING STARTED

CD OR NETWORK ACCESS

a. Not necessary for a CD player to be available
b. It does need Internet access

PROGRAM STARTUP PROCEDURE

a. Click on the link to the web address for the html or swf file
b. Give it a minute to load
c. Click on any of the scenes to start reading or hearing about measurement or significant figures

NORMAL RUNNING OF THE COURSEWARE

TIME TO COMPLETE THE COURSEWARE

It depends on the students' interest levels. The presentation is set up so that students have several opportunities to do formative assessment exercises. There is actually more emphasis on practicing the rules than on getting a single correct answer. This courseware is supposed to be used by students who do not already understand how to do calculations with significant figures and is more of a tutorial than a summative assessment. If students take time to read each scene, it could take them anywhere from an hour to get through all of the scenes and exercises that

have been written, to a couple or even a few hours to reread the rules and redo the exercises.

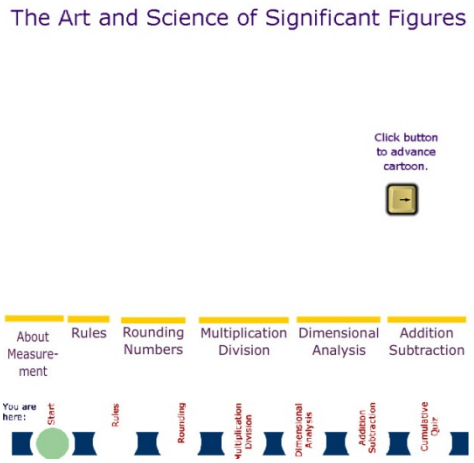
USER INTERFACE COMPONENTS: PARTS OF THE PROGRAM

General operation

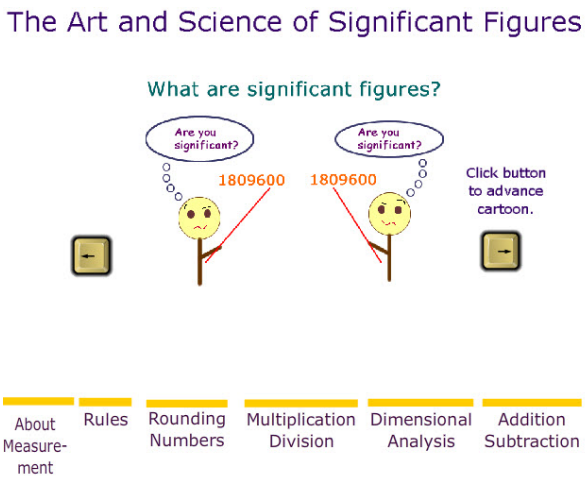
The presentation is packed with buttons and choices. Here are some screenshots to help explain what you are about to encounter.

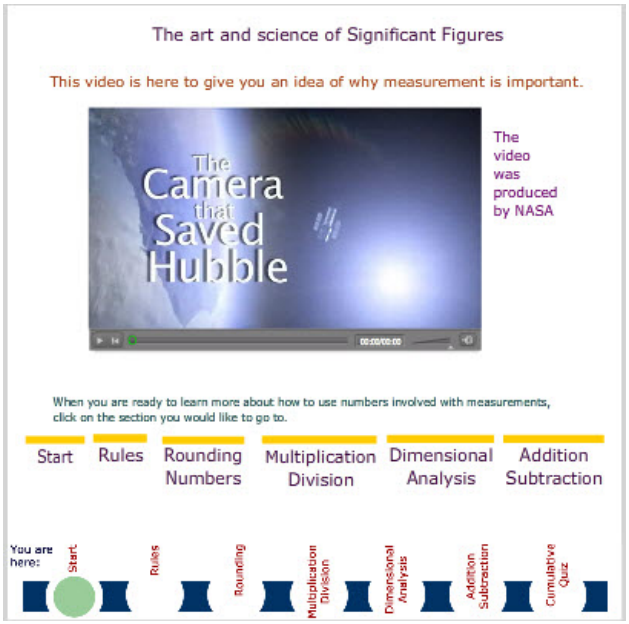
The presentation starts off looking empty. If you click on the button like it suggests, you will get to see the introductory cartoon.

SCENE 1: STARTING AND ABOUT MEASUREMENT

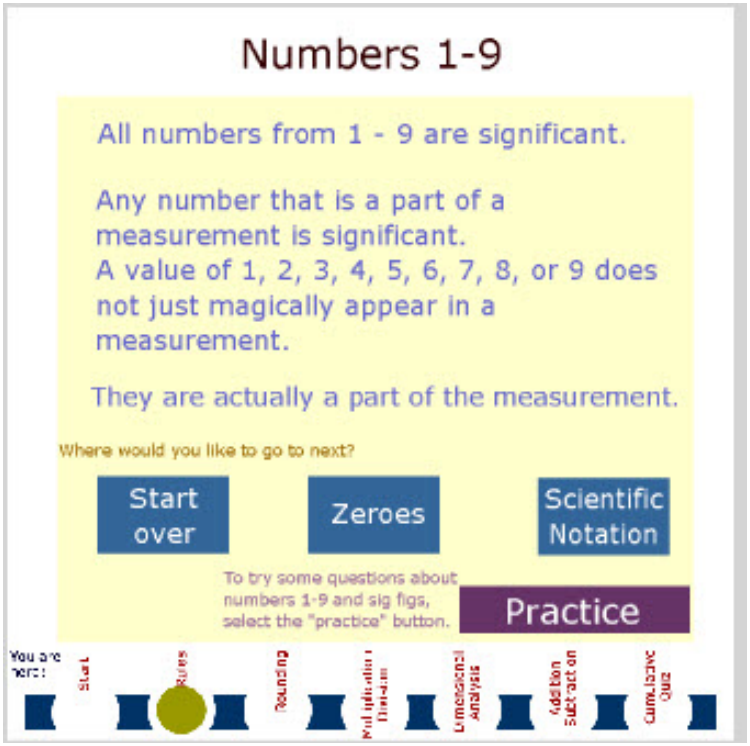


becomes





If you click on the About Measurement button, you will be taken to a NASA video about something that happened when they did not do their original measurement correctly when designing the Hubble telescope. After this scene, the About Measurement button becomes “Start” and clicking on it will bring you back to the blank screen waiting for the cartoon to be loaded.

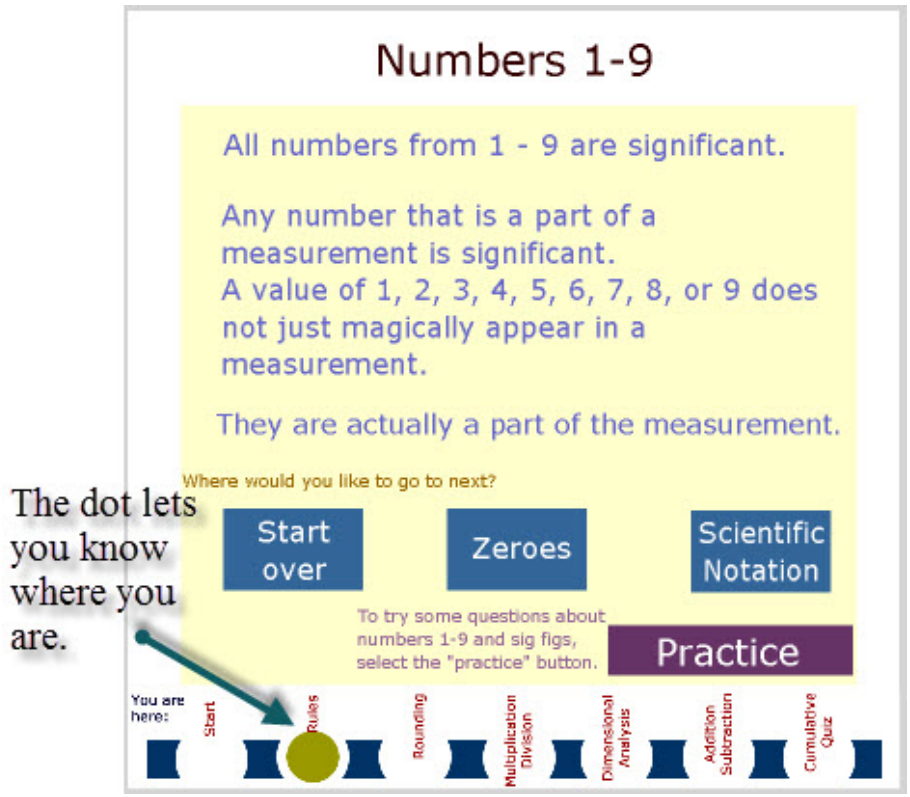


SCENE 2: RULES

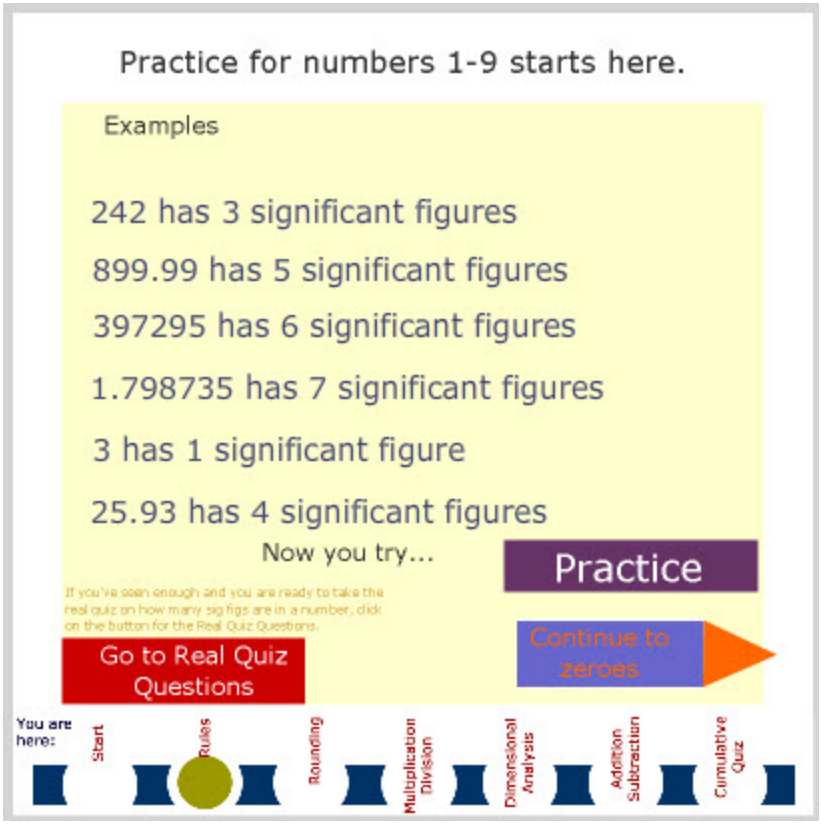
Most people will start off in the Rules scene and do each scene in order from left to right. Here are some screenshots of some of the things you may find and what you can do with them.

Here there are 4 buttons. After reading the rules for numbers 1-9, the players get to choose to start over which takes them back to the start screen, go to the rules on zeroes, or go to the rules on scientific notation.

In the Rules scene, each part has its own practice because being able to use significant figures requires a thorough understanding of what to do with each type of number you come across.

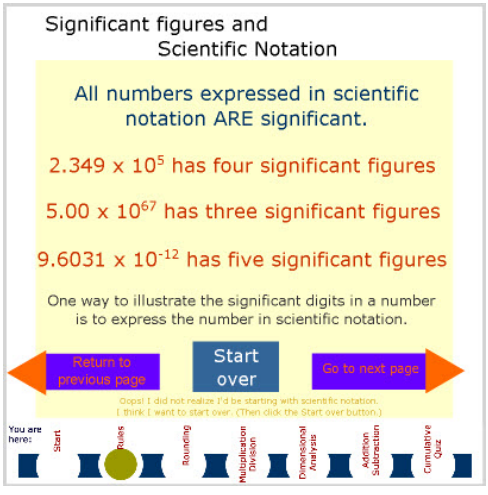


This image is here to emphasize the guide that goes along the bottom of each page. There is a dot next to the name of the scene you are in. For the Rules scene, it happens to be a green dot.

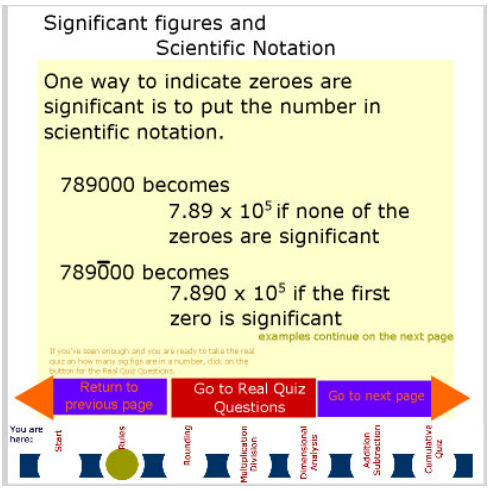


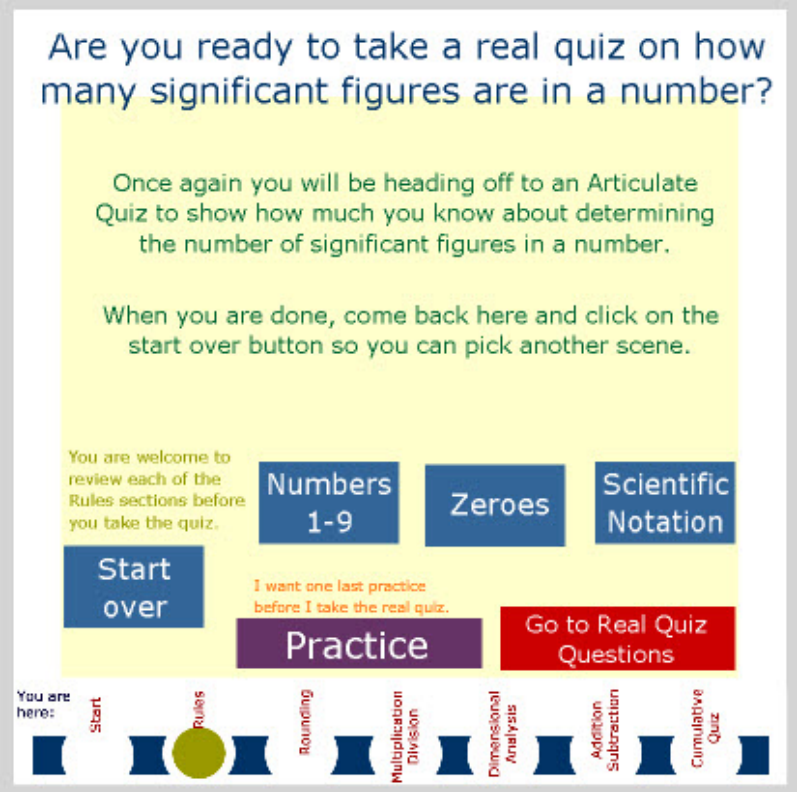
This image shows you what the Practice page looks like for the numbers 1-9 rules. Examples are provided so that players can make sense of what they see and connect how many digits are in the number with how many significant figures are in the number.

Notice there is both a practice and a quiz button. Both of these parts of the exercise were written in Articulate Storyline because the software is easier to use than Flash to write questions. You should allow your browser to open a new tab or window so the exercises can load. The main lesson file will remain open in Flash while you work through the questions in Articulate unless you close your browser's window. The idea is to leave the Flash lesson and go to a new window to practice what you have learned. This also gives you an opportunity to go back to the explanations in Flash if you need to review the content.



Some frames have extra buttons that let you escape, "Start Over", or jump ahead to the quiz without having to continue reading the lesson.

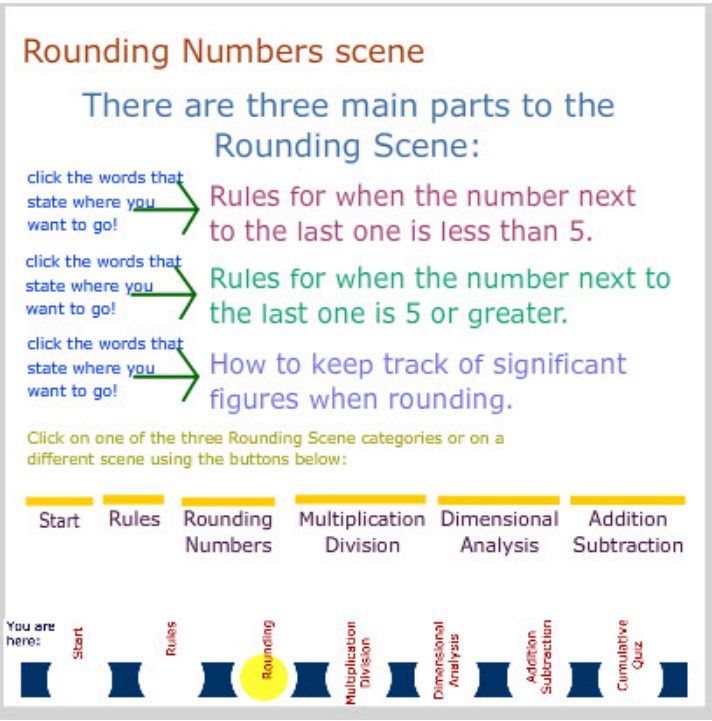


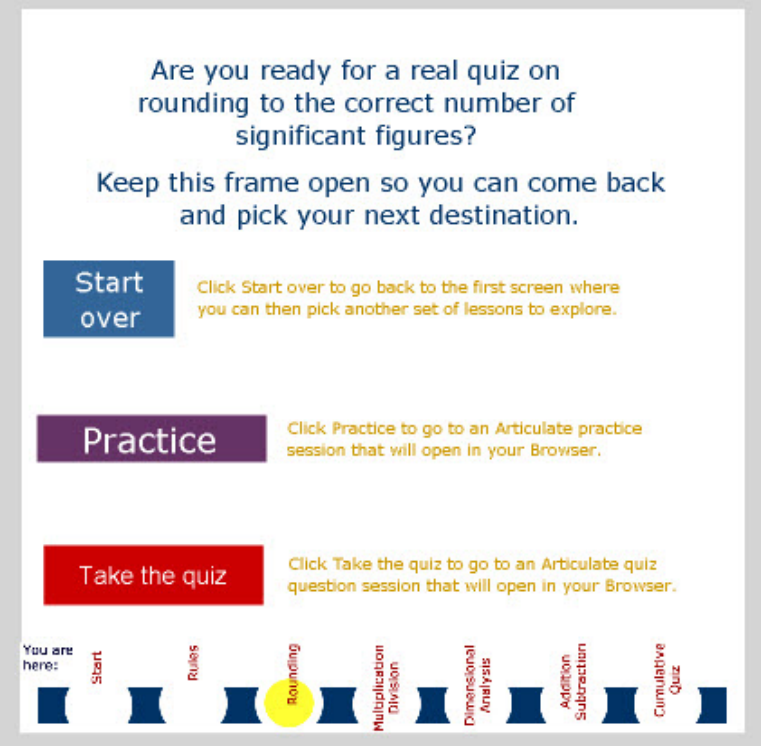


Then comes along the last frame of the Rules Scene: It looks chaotic, but each button has a purpose. Some people may want to review the rules so there is a button that will take players back to the first scene for each section of the rules. Some may not want to do the practice or the quiz and would rather start over, so they will start over. The "Start over" button is also there because this is the frame that will stay open when players go to the Articulate practice or quiz sessions. Upon returning back from the Articulate questions, players will need to choose another scene to visit. Most will continue with the Rounding scene.

sCENE 3: ROUNDING NUMBERS

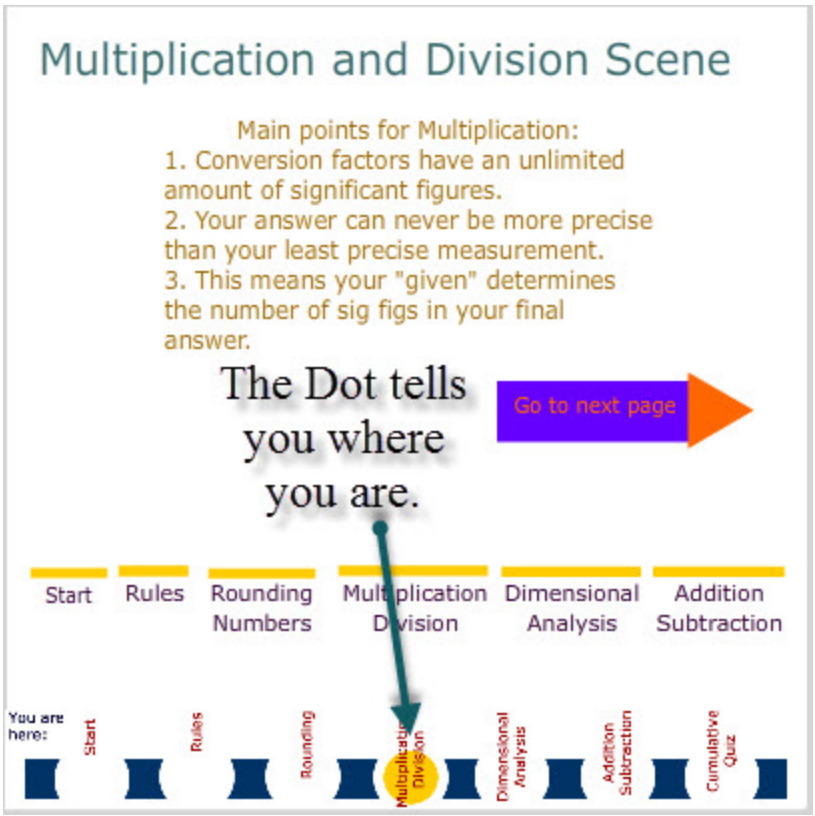
The first frame in the Rounding scene is a little chaotic. Essentially there are two rules for rounding, and since this is about significant figures, there is a third rule just for significant figures. The main rules for rounding are 4 and below, round down or chop off, and 5 and above round up. Since those are even a bit vague, each of those sections is full of examples of how to round various numbers. The section on keeping track of significant figures when rounding is one of the more informative parts of the curriculum. Even if students know how to round, they should at least watch and read through the section on how to keep track of significant figures when also rounding a number. To get to a section that describes the rule and gives examples, click on the title of the section in the right column after the arrows.





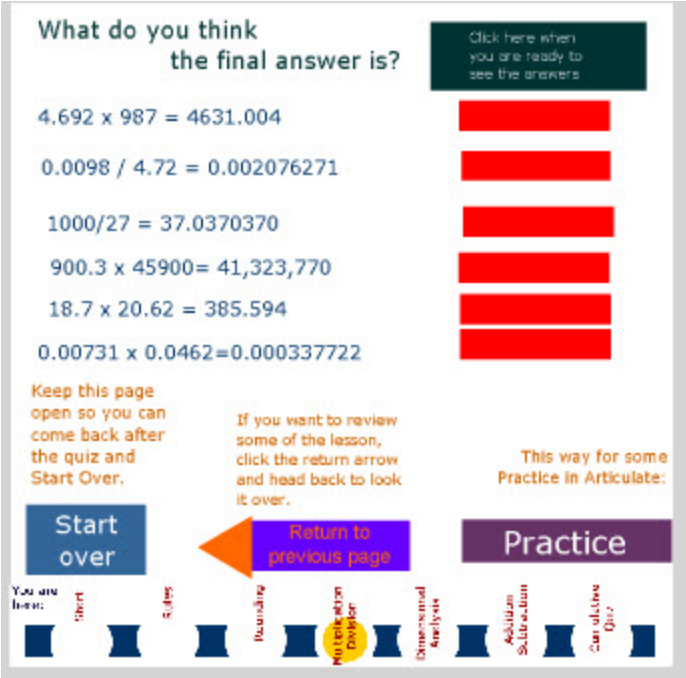
The last frame is similar to the last Rules frame in that it provides students with an opportunity to do practice and quiz questions that involve rounding to a specific number of significant digits. This page should be left open so that after doing the exercises in Articulate's stories, a new scene can be chosen. Most people will continue on to the Multiplication/Division scene because knowing how to round to a certain number of significant figures is not good enough. Students also need to know when to apply the rules and how to do it correctly.

SCENE 4: MULTIPLICATION AND DIVISION WITH SIGNIFICANT FIGURES

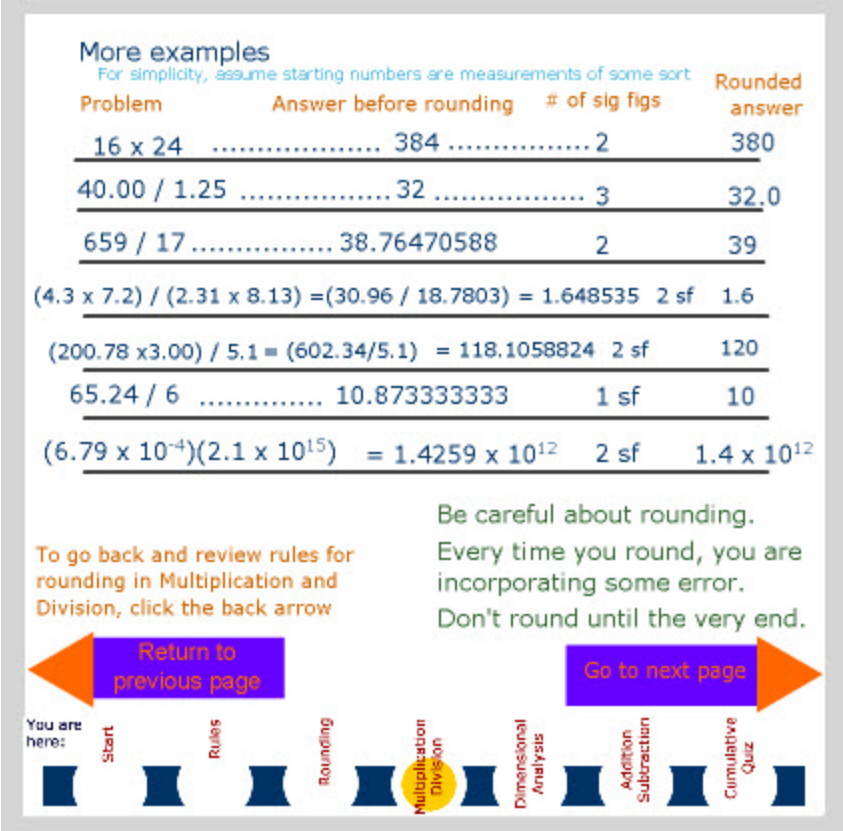


Again, let the dot help you figure out where you are.

The Multiplication and Division scene is not very long, but it is very dense. Those who learn by example will appreciate the frames because they are packed with information. Those who are overwhelmed easily will want to take a deep breath and slowly progress through the examples line by line. The examples are there so you can compare them to each other and look for patterns.



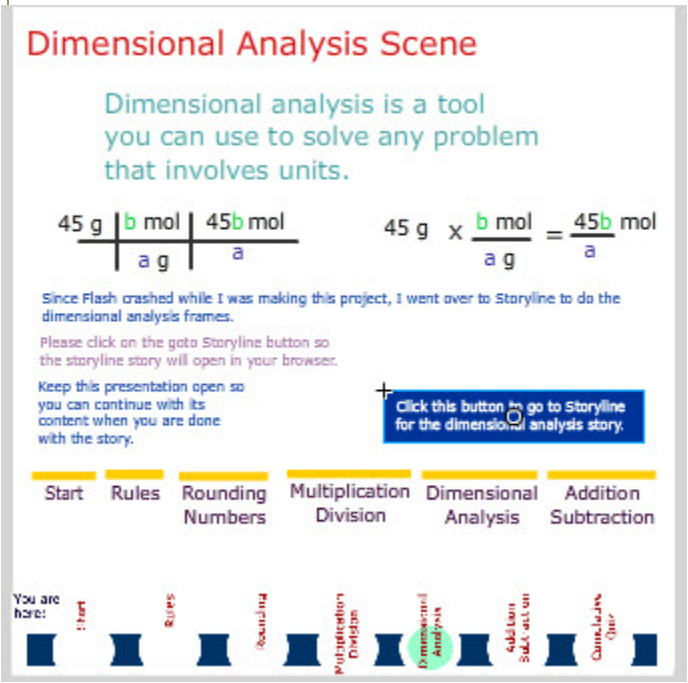
This is one of the frames that has lots of examples. Take the time to notice that first a problem is given, then the answer before rounding. When calculating to a specific number of significant figures, rounding is usually involved. The third column identifies how many significant figures need to be in the final answer. You learn how to determine this in the Multiplication/Division scene. Finally, the last column shows you what the correct answer would be for that problem.



One frame in the Multiplication/ Division scene has a few questions that let students test themselves before they move on to doing more practice questions made in the Articulate software. Again, leave this frame or the next one open (it has a start over button and the answers) so that upon returning to the Flash presentation, a new scene can be chosen.

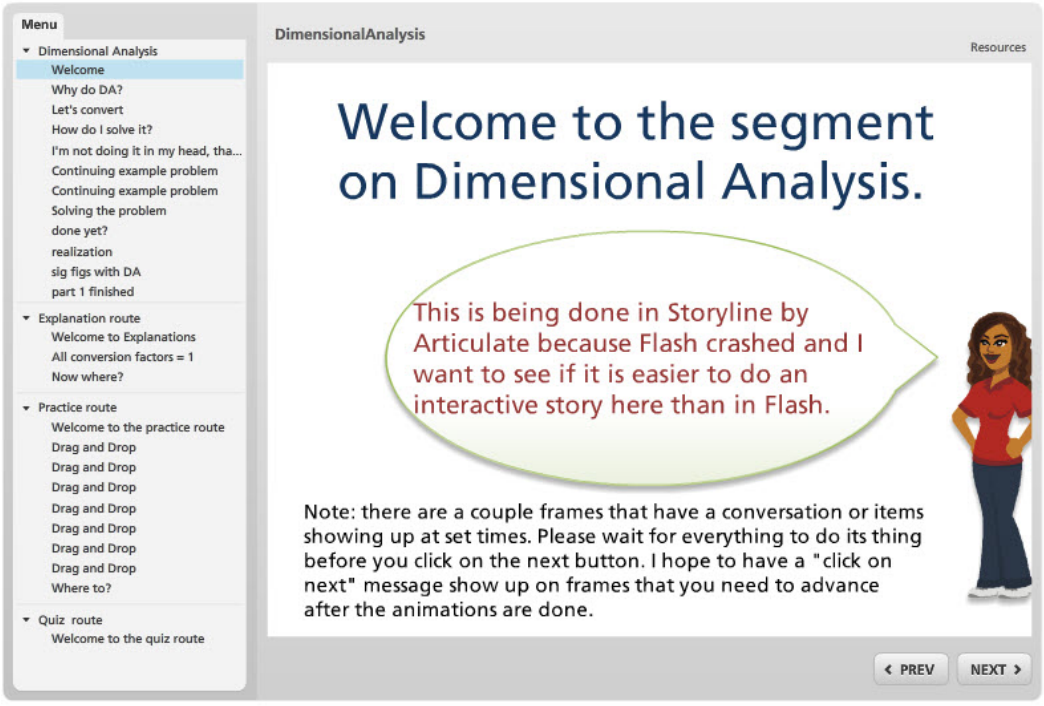
Since conversion factors are unique, the next scene focuses on how to do dimensional analysis and how to handle conversion factors.

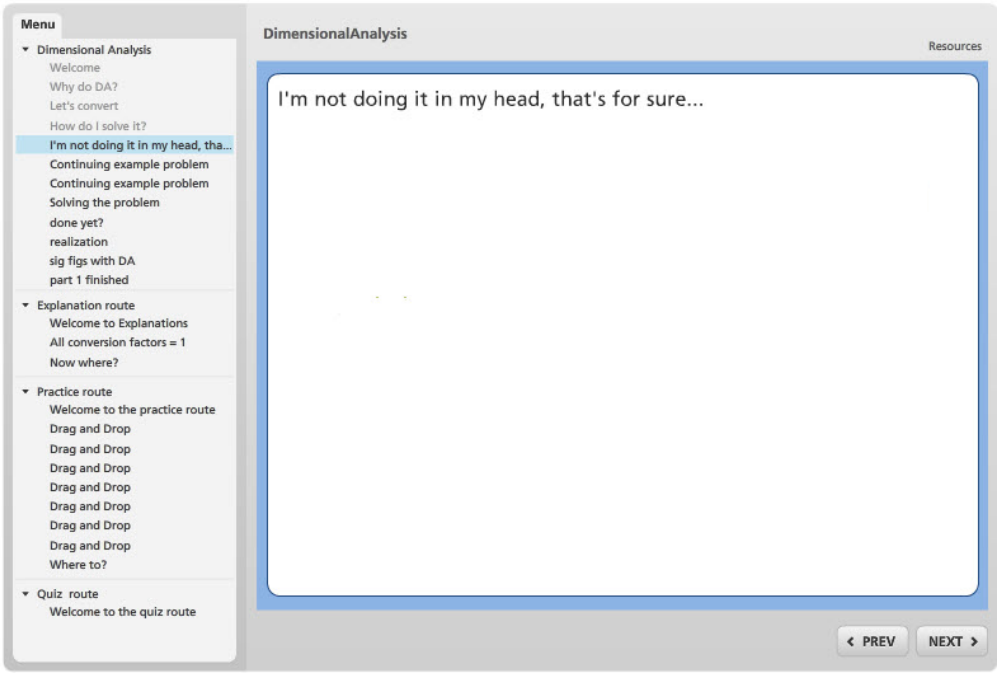
SCENE 5: DIMENSIONAL ANALYSIS



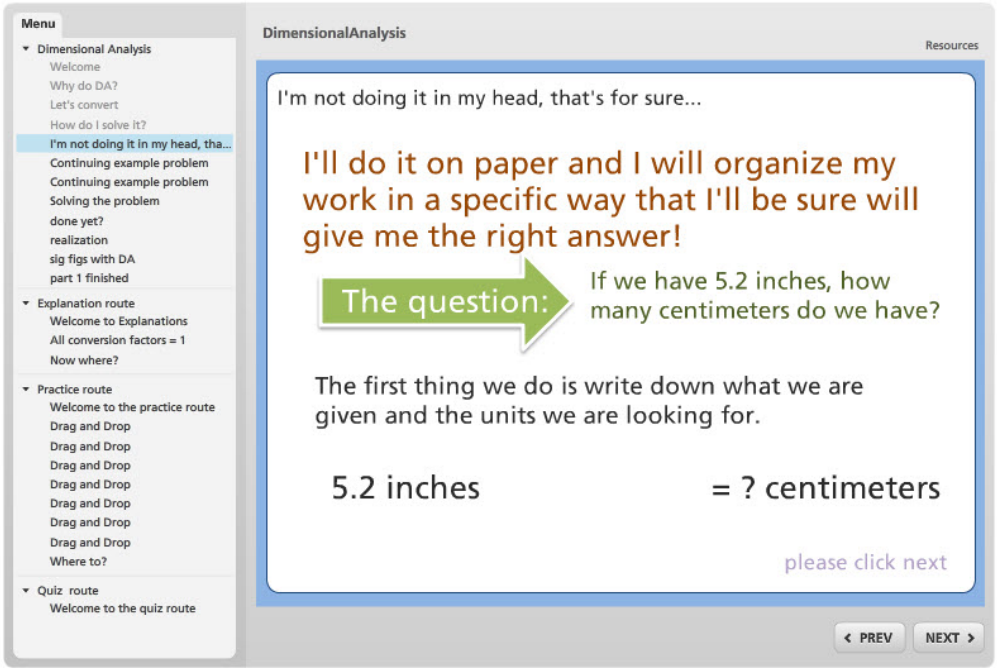
The Dimensional Analysis Scene in Flash is one single frame. Because there are several drag and drop activities in this section, it was created in Articulate's Storyline software. Leave this frame open in Flash to continue on to the last scene, Addition and Subtraction.

The Articulate Storyline software allows there to be a navigation screen in addition to buttons at the bottom of the frames. Most people navigate through using the prev or next buttons. Prev takes you to the previous frame, whereas "Next" takes you to the next frame. Some of the writing in these frames is set on a timer so a frame may look completely empty in the beginning, but by the end of the frame, it is full of content.

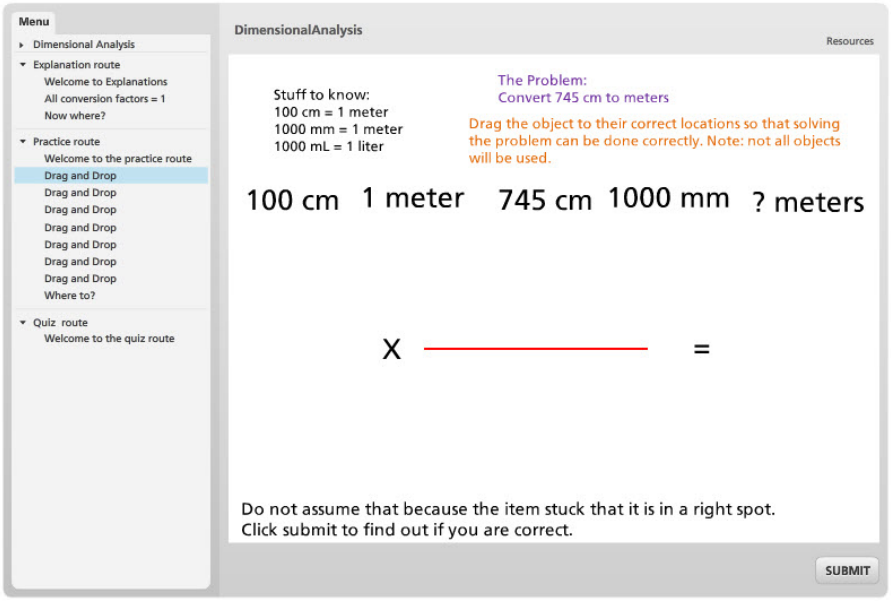




Will become

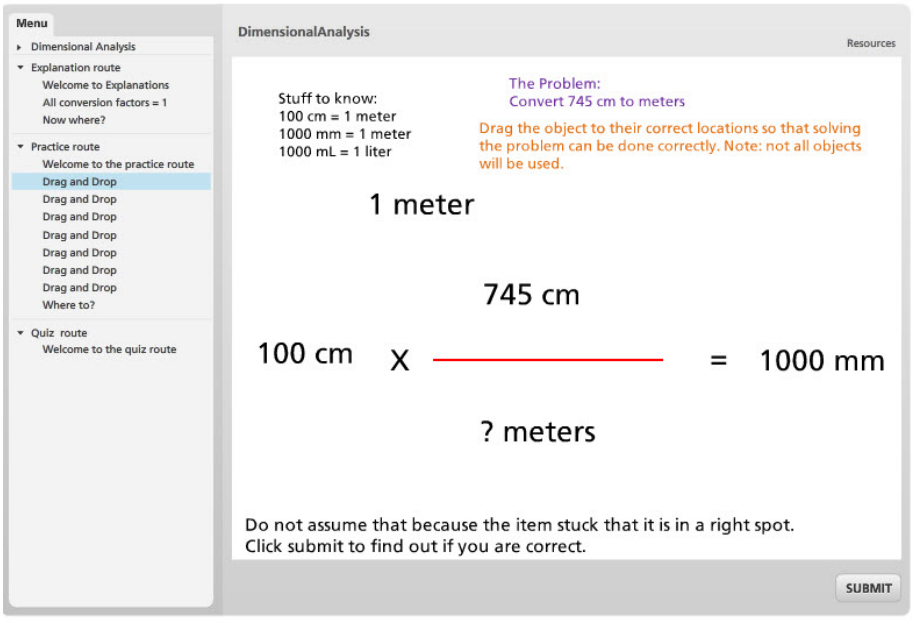


If the viewer is patient and waits for the frame to load.



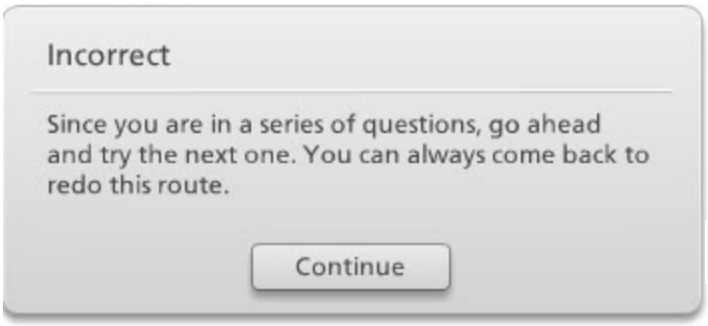
This is an example of a Drag and Drop question. Along the top is some information needed for the problem.

If the submit button is clicked while the structure is still empty, an error statement comes up telling the students to answer the question before submitting it.

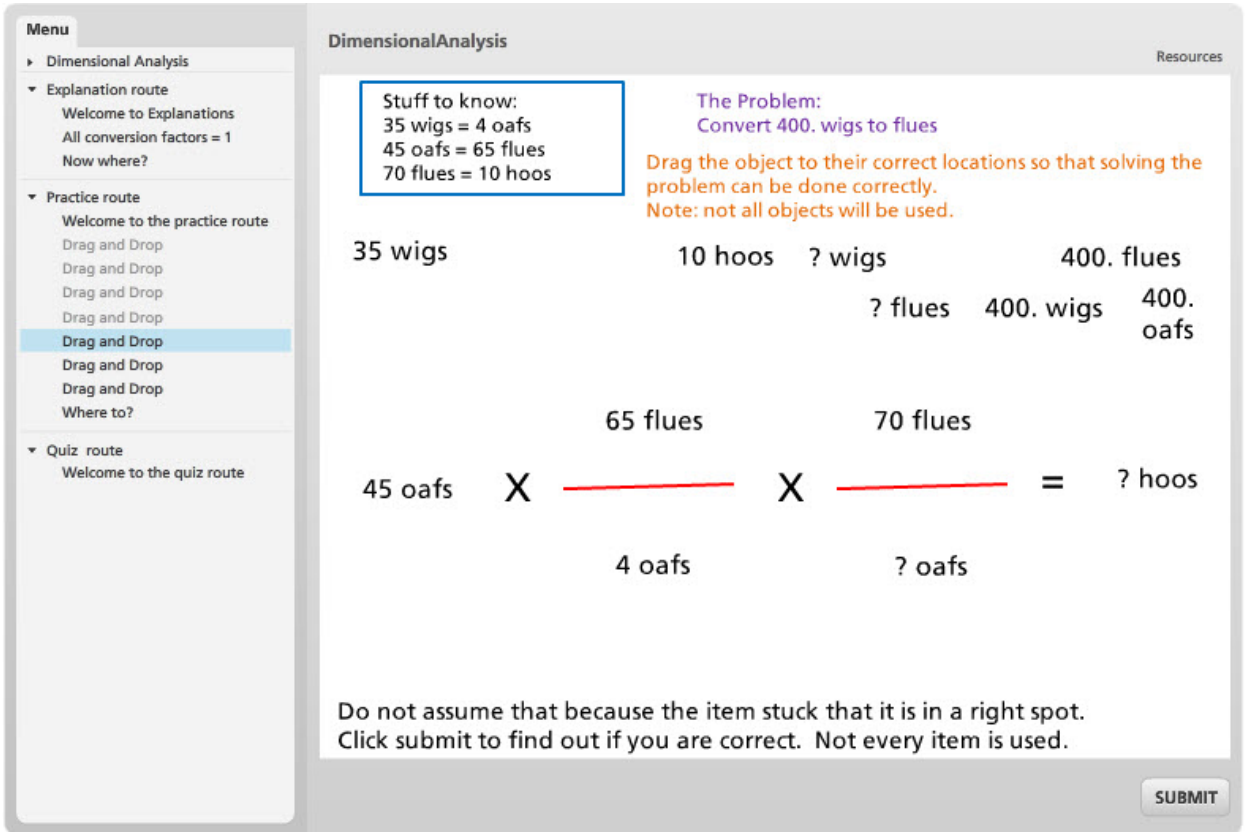


This is what a filled in drag and drop frame can look like.

(These answers are wrong.)

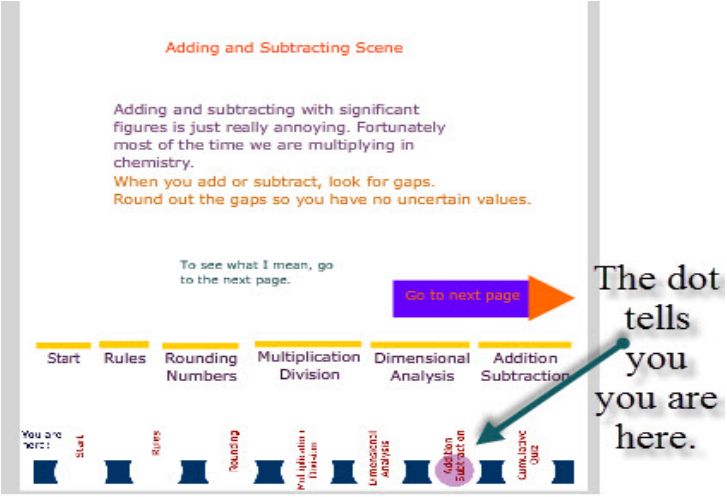


When the answer is wrong, another dialog box pops up to let the student know that it is ok to come back and redo the question at a later time.



The dimensional analysis section covers how to set up not just one conversion factor, but two! Fictional equations are used so students can focus on the structure of dimensional analysis and not on the reality of what is being converted.

SCENE 6: ADDING AND SUBTRACTING WITH SIGNIFICANT FIGURES



Finally, the last scene, Adding and Subtracting explains how keeping track of significant figures when adding or subtracting is different than when multiplying or dividing

ENDING THE PROGRAM

There is no official end of the program, although if things were perfect, there would be a summative assessment at the end made of many of the formative assessment questions as well as some new ones.

TROUBLESHOOTING

Hopefully nothing will go wrong, but these are some things that might:

1. The sound effects don't work. If that happens, it is no big deal. They were there mainly for entertainment purposes anyway.
2. The video does not load. That would be unfortunate because a lot of care was done to make sure it was properly embedded and was viewable. An online version of the video with podcasting notes can be found at: http://www.nasa.gov/multimedia/podcasting/jpl-wfpc-20090507.html
3. Articulate scenes may not open in a new window like I tried to program them to do. In that case, the students may want to use two different browsers- one for the Flash presentation and another one just to launch the quizzes or parts made in Articulate Storyline.
4. Some of the buttons may not work even though I've gone through it many times to make sure each one takes you somewhere. Ideally there will be more than one way to approach any scene and there are hopefully many opportunities to return to the original starting page so students can start over if they choose.
5. A "where am I?" mini-map was added to the bottom so people would at least know which scene they were in.

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